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IS 4493-7 (1983): Hollow metallic waveguides, Part 7:
Circular waveguides [LITD 6: Wires, Cables, Waveguides and
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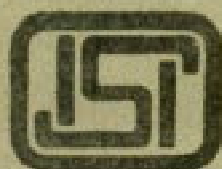
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IS : 4493 (Part 7) - 1983

Indian Standard
SPECIFICATION FOR
HOLLOW METALLIC WAVEGUIDES
PART 7 CIRCULAR WAVEGUIDES

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

SPECIFICATION FOR HOLLOW METALLIC WAVEGUIDES

PART 7 CIRCULAR WAVEGUIDES

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(Continued on page 2)

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(Continued from page 1)

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Indian Standard
**SPECIFICATION FOR
HOLLOW METALLIC WAVEGUIDES**
PART 7 CIRCULAR WAVEGUIDES

0. F O R E W O R D

0.1 This Indian Standard (Part 7) was adopted by the Indian Standards Institution on 20 September 1983, after the draft finalized by the Microwave Components and Accessories Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard (Part 7) covers the requirements for hollow metallic tubing, circular waveguides.

0.2.1 The series of circular waveguides covered by this standard are given in Tables 1A and 1B. The preferred types are given in Table 1A. As it might be desirable to use circular waveguides of intermediate sizes, these have been included in Table 1B.

0.3 This standard shall be used in conjunction with IS : 4493 (Part 1)-1979*.

0.4 Different types of waveguides are being covered in a series comprising the following individual parts of IS : 4493 :

- Part 1 General requirements and tests
- Part 2 Ordinary rectangular waveguides
- Part 3 Medium flat rectangular waveguides
- Part 4 Flat rigid rectangular waveguides
- Part 5 Rigid rectangular waveguides with circular outside cross section
- Part 6 Rigid square waveguides
- Part 7 Circular waveguides
- Part 8 Elliptical waveguides

*Specification for hollow metallic waveguides : Part 1 General requirements and tests (first revision).

IS : 4493 (Part 7) - 1983

0.5 While preparing this standard, assistance has been derived from the following :

- a) IEC Pub 153-4 Hollow metallic waveguides: Part 4 Relevant specifications for circular waveguides. International Electro-technical Commission.
- b) JSS 53005 Detail specification for waveguides, rigid, circular. Ministry of Defence, India.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 7) specifies the requirements for hollow metallic tubing, circular waveguides for use in electronic and telecommunication equipment.

2. TERMINOLOGY

2.1 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part 13/Sec 2)-1967† and IS : 4493 (Part 1)-1979‡ shall apply.

3. CLIMATIC CATEGORIES

3.1 For the purpose of climatic tests, the waveguides shall belong to one of the following categories:

Severity	Category 1	Category 2	Category 3
Dry heat	+100°C	+100°C	+85°C
Cold	—65°C	—40°C	—10°C
Rapid change of temperature	—65° to +100°C	—40° to +100°C	—10° to +85°C

NOTE 1 — For waveguides used in aviation, climatic category 1 would be applicable.

NOTE 2 — For waveguides used on ground equipment (fixed or mobile), climatic category 2 would be applicable.

NOTE 3 — For waveguides used for general purpose in laboratory, climatic category 3 would be applicable.

*Rules for rounding off numerical values (revised).

†Electrotechnical vocabulary: Part 13 Telecommunication transmission lines and waveguides, Section 2 Microwave transmission lines and waveguides.

‡Specification for hollow metallic waveguides: Part 1 General requirements and tests (first revision).

4. MATERIAL, CONSTRUCTION AND WORKMANSHIP

4.1 Provisions of 4 of IS : 4493 (Part 1)-1979* shall apply.

5. DESIGNATION OF WAVEGUIDES

5.1 Provisions of 6 of IS : 4493 (Part 1)-1979* shall apply.

6. MARKING

6.1 Provisions of 7 of IS : 4493 (Part 1)-1979* shall apply.

7. PACKAGING

7.1 Provisions of 8 of IS : 4493 (Part 1)-1979* shall apply.

8. DIMENSIONAL REQUIREMENTS

8.1 The outline and dimensions shall be in accordance with Tables 1A and 1B.

9. ELECTRICAL CHARACTERISTICS

9.1 The electrical characteristics shall be as specified in Table 1.

10. CONDITIONS FOR TESTS

10.1 Provisions of 9.1 of IS : 4493 (Part 1)-1979* shall apply.

11. CLASSIFICATION OF TESTS

11.1 Provisions of 9.2 of IS : 4493 (Part 1)-1979* shall apply.

11.2 The schedule for mechanical, electrical and climatic tests and their requirements shall be as specified in Table 2.

12. TECHNICAL INFORMATION

12.1 Nominal Internal Diameter and Operating Frequency Range — To permit selection of optimum waveguide sizes two overlapping series are listed. Cutoff frequencies for the TE_{11} (dominant mode), TM_{01} , TE_{21} , TE_{01} and TE_{02} modes are shown. The recommended frequency range for the TE_{11} mode operation is within 1.15 times the cutoff frequency for the TE_{11} mode and 0.95 times the cutoff frequency for the TE_{21} mode. The recommended frequency range for the TE_{01} mode operation is within 1.21 times the cutoff frequency for the TE_{01} mode and 0.91 times the cutoff frequency for the TE_{02} mode.

*Specification for hollow metallic waveguides: Part 1 General requirements and tests (first revision).

12.2 Tolerance on Internal Diameter — Tolerances for the internal diameter are in principle $\pm 1/1\,000$ of the internal diameter. For sizes C 190 and smaller, tolerances are under consideration.

12.3 Theoretical Attenuation — The values given in Table 1A are based on a figure for resistivity of copper of $1.724 \times 10^{-8} \Omega\text{m}$ and apply to a frequency equal to $1.2 f_c$ (for TE_{11} mode).

For general case, attenuation is calculated by the formula given in 9.3.1 of IS : 4493 (Part 1)-1979*. For other materials, the figures quoted should be multiplied by the values specified in 5.1 of IS : 4493 (Part 1)-1979*.

NOTE — The values of attenuation given in Table 1A are for 100 percent copper. For other materials these values can be calculated using the formula given below [see also 9.3 of IS : 4493 (Part 1)-1979*] :

This formula do not apply for thinly plated surface. Circular waveguides H_{11} (TE_{11}) mode;

$$\alpha = 5.040 \left(\frac{P}{P_o} \right)^{\frac{1}{2}} \cdot \frac{1}{D^{3/2}} \cdot \frac{1 + 0.4185 \left(\frac{f}{f_c} \right)^2}{\left(\frac{f}{f_c} \right)^{\frac{1}{2}} \left[\left(\frac{f}{f_c} \right)^2 - 1 \right]^{\frac{1}{2}}} \text{ dB/m}$$

P = resistivity of inside non-magnetic wall metal,

P_o = resistivity of copper = 1.724×10^{-8} ohm metre,

D = inner diameter in millimetres,

f_c = Cut-off frequency for H_{11} (TE_{11}) mode = $\frac{175.703}{D}$ GHz, and

f = frequency at which the attenuation is to be calculated.

These values also can be evaluated by multiplying the values obtained for 100 percent copper by (p/p_o) where p_o is the resistivity of copper which is equal to 1.724×10^{-8} ohm metre and p is the resistivity of the material used. For guidance, multiplication factors for a few materials are given below :

$$\frac{0.421 (f/f_c)^2 + 1}{(f/f_c)^{\frac{1}{2}} [(f/f_c)^2 - 1]^{\frac{1}{2}}}$$

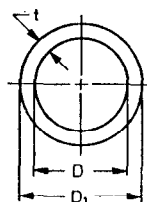
For other materials the figures quoted should be multiplied by :

Material	Resistivity Ohm metre $\times 10^{-8}$	Multiplied by
Silver 100 percent	1.56	0.98
Copper (ETP)†	1.72	1.00
Silver (7½ percent copper)	1.80	1.06
Aluminium (100 percent)	2.83	1.30
Brass (90 percent copper)	3.90	1.55
Magnesium (100 percent)	4.60	1.68
Brass (70 percent copper)	6.50	2.00

*Specification for hollow metallic waveguides: Part 1 General requirements and tests (first revision).

†Pure high conductivity electrolytic tough pitch copper (ETP) conforming to IS : 191-1967 Specification for copper (second revision).

TABLE 1A CIRCULAR WAVEGUIDES (PREFERRED)
(*Clauses 0.2.1, 8.1 and 12.3*)



All dimensions in millimetres.

TYPE DESIGN- ATION	CUT-OFF FREQUENCY IN GHZ FOR THE MODE					INSIDE CROSS-SECTION		BASIC WALL THICKNESS <i>t</i>	OUTSIDE CROSS-SECTION		ATTENUATION IN dB/m IN THE H_{11} (TE_{11}) MODE		
	H_{11} (TE_{11})	E_{01} (TM_{01})	H_{21} (TE_{21})	H_{01} (TE_{02})	H_{02} (TE_{03})	Basic Diameter <i>D</i>	Deviation* \pm		Basic Diameter <i>D</i> ₁	Deviation† \pm	Frequency in GHz	Theoretical Value	Maximum Value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
C3.3	0.27	0.35	0.45	0.56	1.03	647.90	0.65	—	—	—	0.325	0.000 67	0.000 9
C4	0.32	0.41	0.53	0.66	1.21	553.50	0.55	—	—	—	0.380	0.000 85	0.001 1
C4.5	0.37	0.48	0.62	0.77	1.42	472.80	0.47	—	—	—	0.446	0.001 08	0.001 4
C5.3	0.43	0.57	0.72	0.90	1.66	403.90	0.40	—	—	—	0.522	0.001 37	0.001 8
C6.2	0.51	0.66	0.84	1.06	1.94	345.10	0.35	—	—	—	0.611	0.001 74	0.002 3
C7	0.60	0.78	0.99	1.24	2.27	294.79	0.30	—	—	—	0.715	0.002 19	0.002 9
C8	0.70	0.91	1.16	1.45	2.66	251.84	0.25	—	—	—	0.838	0.002 78	0.003 6
C10	0.82	1.07	1.35	1.70	3.11	215.14	0.22	—	—	—	0.980	0.003 52	0.004 6
C12	0.96	1.25	1.59	1.99	3.64	183.77	0.18	—	—	—	1.147	0.004 47	0.005 8
C14	1.12	1.46	1.86	2.33	4.26	157.00	0.16	—	—	—	1.343	0.005 64	0.007 3
C16	1.31	1.71	2.17	2.73	4.99	134.11	0.13	—	—	—	1.572	0.007 15	0.009 3
C18	1.53	2.00	2.54	3.19	5.84	114.58	0.11	3.30	121.20	0.13	1.841	0.009 06	0.012
C22	1.79	2.34	2.98	3.74	6.84	97.87	0.10	3.30	104.50	0.11	2.154	0.011 5	0.015
C25	2.10	2.74	3.49	4.37	8.01	83.62	0.08	3.30	90.20	0.11	2.521	0.014 0	0.018
C30	2.46	3.21	4.08	5.12	9.37	71.42	0.07	3.30	78.030	0.095	2.952	0.018 4	0.024
C35	2.88	3.76	4.77	5.99	11.0	61.04	0.06	3.30	67.640	0.095	3.455	0.023 3	0.030
C40	3.38	4.41	5.61	7.03	12.9	51.99	0.05	2.54	57.070	0.095	4.056	0.029 7	0.039
C48	3.95	5.16	6.56	8.23	15.1	44.450	0.044	2.54	49.530	0.080	4.744	0.037 5	0.049
C56	4.61	6.02	7.65	9.60	17.6	38.100	0.038	2.03	42.160	0.080	5.534	0.047 3	0.062
C65	5.40	7.05	8.96	11.2	20.6	32.537	0.033	2.03	36.600	0.080	6.480	0.059 9	0.078
C76	6.32	8.26	10.5	13.2	24.1	27.788	0.028	1.65	31.090	0.080	7.588	0.075 9	0.099
C89	7.37	9.63	12.2	15.3	28.1	23.825	0.024	1.65	27.127	0.065	8.850	0.095 6	0.124
C104	8.68	11.3	14.4	18.1	33.1	20.244	0.020	1.270	22.784	0.065	10.42	0.122 0	0.150
C120	10.0	13.1	16.7	20.9	38.3	17.475	0.017	1.270	20.015	0.065	12.07	0.152 4	—
C140	11.6	15.2	19.3	24.2	44.4	15.088	0.015	1.015	17.120	0.055	13.98	0.189 3	—
C165	13.8	18.1	22.9	28.8	52.7	12.700	0.013	1.015	14.732	0.055	16.61	0.245 9	—
C190	15.8	20.6	26.2	32.9	60.2	11.125	0.010	1.015	13.157	0.050	18.95	0.300 3	—
C220	18.4	24.1	30.6	38.4	70.3	9.525	0.010	0.760	11.049	0.050	22.14	0.378 7	—
C255	21.1	27.5	35.0	43.9	80.4	8.331	0.008	0.760	9.855	0.050	25.31	0.462 0	—
C290	24.6	32.2	40.8	51.2	93.8	7.137	0.008	0.760	8.661	0.050	29.54	0.583 4	—
C330	27.7	36.1	45.9	57.6	105	6.350	0.008	0.510	7.366	0.050	33.20	0.693 8	—
C380	31.6	41.3	52.4	65.7	120	5.363	0.008	0.510	6.579	0.050	37.91	0.848 6	—
C430	36.8	48.1	61.0	76.6	140	4.775	0.008	0.510	5.791	0.050	44.16	1.065 0	—
C495	40.2	52.5	66.7	83.7	153	4.369	0.008	0.510	5.385	0.050	48.26	1.219 0	—
C580	49.1	64.1	81.4	102	187	3.581	0.008	0.510	4.597	0.050	58.88	1.643	—
C660	55.3	72.3	91.8	115	211	3.175	0.008	0.380	3.937	0.050	66.41	1.967	—
C765	63.5	82.9	105	132	242	2.769	0.008	0.380	3.531	0.050	76.15	2.413	—
C890	73.6	96.1	122	153	280	2.388	0.008	0.380	3.150	0.050	88.30	3.011	—

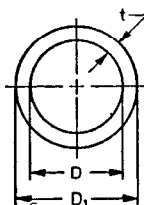
*For information only.

†Deviation — Algebraical difference between a size (actual, maximum, etc) and the corresponding basic size.

Upper Deviation — Algebraical difference between the maximum limit of size and the corresponding basic size.

Lower Deviation — Algebraical difference between the minimum limit of size and the corresponding basic size.

It should be noted that the upper and lower deviations may have like signs, unlike signs or either deviation may be zero. This permits the basic sizes of mating shafts and holes to be identical.

TABLE 1B CIRCULAR WAVEGUIDES (INTERMEDIATE VALUES)
(Clauses 0.2.1 and 8.1)

All dimensions in millimetres.

TYPE DESIGNATION (1)	INTERMEDIATE VALUES FOR BASIC INSIDE DIAMETER (2)	TYPE DESIGNATION (1)	INTERMEDIATE VALUES FOR BASIC INSIDE DIAMETER (2)	TYPE DESIGNATION (1)	INTERMEDIATE VALUES FOR BASIC INSIDE DIAMETER (2)	TYPE DESIGNATION (1)	INTERMEDIATE VALUES FOR BASIC INSIDE DIAMETER (2)
C3.3	647.90	C16	134.11	C76	27.788	C330	6.350
C3.43	623.00	C16.5	129.00	C80.0	26.700	C348	6.140
C3.56	599.00	C17.2	124.00	C83.1	25.700	C359	5.940
C3.71	576.00	C17.9	119.00	C86.1	24.800	C372	5.740
C4	553.50	C18	114.58	C89	23.825	C380	5.563
C4.01	532.00	C19.4	110.00	C93.2	22.900	C398	5.360
C4.17	512.00	C20.1	106.00	C97.0	22.000	C414	5.160
C4.34	492.00	C20.9	102.00	C101	21.100	C429	4.950
C4.5	472.80	C22	97.87	C104	20.244	C430	4.775
C4.69	455.00	C22.7	94.00	C109	19.500	C457	4.670
C4.88	437.00	C23.6	90.40	C114	18.800	C467	4.570
C5.08	420.00	C24.5	87.00	C118	18.150	C478	4.470
C5.3	403.90	C25	83.62	C120	17.475	C495	4.369
C5.50	388.00	C26.6	80.40	C127	16.850	C512	4.170
C5.72	373.00	C27.7	77.20	C129	16.250	C539	3.960
C5.95	359.00	C28.7	74.40	C136	15.650	C568	3.760
C6.2	345.10	C30	71.42	C140	15.088	C580	3.581
C6.43	332.00	C31.1	68.60	C148	14.450	C613	3.480
C6.69	319.00	C32.3	66.00	C154	13.850	C632	3.380
C6.95	307.00	C33.7	63.40	C161	13.250	C651	3.280
C7	294.79	C35	61.04	C165	12.700	C660	3.175
C7.54	283.00	C36.4	58.60	C174	12.300	C696	3.070
C7.85	272.00	C37.8	56.40	C179	11.900	C721	2.960
C7.99	262.00	C39.4	54.20	C186	11.500	C746	2.860
C8	251.84	C40	51.99	C190	11.125	C765	2.769
C8.82	242.00	C42.7	50.00	C198	10.760	C799	2.670
C9.16	233.00	C44.4	48.10	C207	10.300	C831	2.570
C9.53	224.00	C46.2	46.20	C219	9.700	C876	2.440
C10	215.14	C48	44.450	C220	9.525	C890	2.388
C10.3	207.00	C49.9	42.800	C232	9.220		
C10.7	199.00	C51.8	41.200	C239	8.920		
C11.2	191.00	C53.9	39.600	C248	8.620		
C12	183.77	C56	38.100	C255	8.331		
C12.1	176.50	C58.3	36.600	C266	8.020		
C12.6	170.00	C60.6	35.200	C277	7.720		
C13.1	163.50	C63.2	33.800	C288	7.420		
C14	157.00	C65	32.537	C290	7.137		
C14.1	151.00	C68.2	31.300	C308	6.940		
C14.7	145.00	C70.9	30.100	C317	6.740		
C15.3	139.50	C73.9	28.900	C327	6.520		

NOTE — To facilitate reference, all the preferred sizes given in Table 1A have also been included in this table.

TABLE 2 TEST SCHEDULE AND REQUIREMENTS
(Clause 11.2)

SL No.	TEST	METHODS OF MEASUREMENT	REQUIREMENTS
(1)	(2)	Clause Reference in IS : 4493 (Part 1)-1979*	
		(3)	(4)
1. <i>All Samples</i>			
	a) Visual examination	9.4.1	The waveguides shall be visually examined and condition, design, workmanship, finish and markings shall be satisfactory. There shall be no burrs, cracks, pits or other irregularities of the surface. Both inner and outer surfaces shall have a clean bright appearance in accordance with current engineering practice and shall be free from oxidation
	b) Dimensions	9.4.2	Besides this, the dimension and tolerance thereon shall conform to values given in Table 1A of this standard. And the ellipticity <i>E</i> shall not exceed 0.001 at any cross-section for types C3.3 to C165 inclusive
			NOTE — For sizes C190 and smaller dimensions, the requirement for ellipticity is under consideration
	c) Bow	9.4.3	9.4.3
2. <i>First Group</i>			
	Surface roughness	9.4.8	9.4.8
3. <i>Second Group</i>			
	Internal stresses	9.4.9	9.4.9
4. <i>Third Group</i>			
	Attenuation	9.3.1	As specified in Table 1A of this standard

*Specification for hollow metallic waveguides : Part 1 General requirements and tests (*first revision*).

(Continued)

TABLE 2 TEST SCHEDULE AND REQUIREMENTS — *Contd*

SL No.	TEST	METHODS OF MEASUREMENT	REQUIREMENTS
Clause Reference in IS : 4493 (Part 1)-1979*			
(1)	(2)	(3)	(4)
5. Fourth Group			
	a) Dry heat†	As per IS : 9000 (Part 3/Sec 2) - 1977‡	—
	i) Visual examination		The waveguides shall be visually examined and condition, design, workmanship, finish and markings shall be satisfactory. There shall be no burrs, cracks, pits or other irregularities of the surface. Both inner and outer surfaces shall have a clean bright appearance in accordance with current engineering practice and shall be free from oxidation.
	ii) Bow	9.4.3	The requirements shall be within the limits specified in this standard.
	iii) Ellipticity	9.4.2.3	The requirements shall be within the limits specified in this standard.
	b) Cold‡	As per IS : 9000 (Part 2/Sec 2) - 1977§	After recovery under standard atmospheric conditions, measurements specified as in dry heat test shall be made and the requirements shall be met as specified in this standard.
	c) Rapid change of temperature	9.5.3 (Not less than 30 minutes)	After recovery under standard atmospheric conditions, measurements specified as in dry heat test shall be made and the requirements shall be met as specified in this standard.

*Specification for hollow metallic waveguides: Part 1 General requirements and tests (*first revision*).

†Duration for these tests is under consideration.

‡Basic environmental testing procedures for electronic and electrical items: Part 3 Dry heat test, Section 2 Dry heat test for non-heat dissipating items with sudden change of temperature.

§Basic environmental testing procedures for electrical items: Part 2 Cold test, Section 2 Cold test for non-heat dissipating items with sudden change of temperature.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s ²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m ²
Frequency	hertz	Hz	1 Hz = 1 c/s (s ⁻¹)
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m ²

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